OVIPOSITION BY WATER BUGS (HEMIPTERA: CORIXIDAE) INDUCES CHANGES IN DISSOLVED OXYGEN AND TURBIDITY MEASUREMENTS IN THOMSONS LAKE, WESTERN AUSTRALIA.

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ABSTRACT

In a sequence of data recorded at 15 minute intervals in a shallow lake in Western Australia, marked steps upward in turbidity and a significant drop in dissolved oxygen coincided with a period of oviposition by aquatic Hemiptera (Corixidae). It is proposed that the steps in the turbidity data reflect the times of oviposition and that the drop in dissolved oxygen can be attributed to respiration by the Corixidae.

INTRODUCTION

In recent years the collection of large quantities of data with a high degree of spatial and temporal resolution has become commonplace in lakes due to advances in the technology associated with instrumentation and data storage (Imberger, 1994). The instruments are generally not deployed underwater for extended periods of time, as fouling from biological activity and deterioration of the equipment compromises the accuracy of the readings. In instances of prolonged data collection, a regular schedule of maintenance and recalibration is usually required to keep measurement errors to a minimum. If there is a fouling event between instrument checks the data set may be useless for the original purposes of the study. Alternatively, such an event may provide information about the organisms responsible for the fouling.

In a study conducted between 1 August 1994 and 29 November 1994, data were collected from the shallow Thomsons Lake at 15 minute intervals continuously over periods ranging from 3 to 10 days. The objective of this study was to examine the relationships between wind, light, fluorescence and physical properties of the water column over short time scales. During a 5 day data collection period in November 1994 an oviposition event caused fouling of the instruments. The event coincided with anomalous measurements of dissolved oxygen and turbidity in the lake on 17 and 18 November 1994.

Identification of the eggs (see Fig.2) indicated that they were deposited by an aquatic water bug of the family Corixidae (Hinton, 1981; CSIRO, 1991).

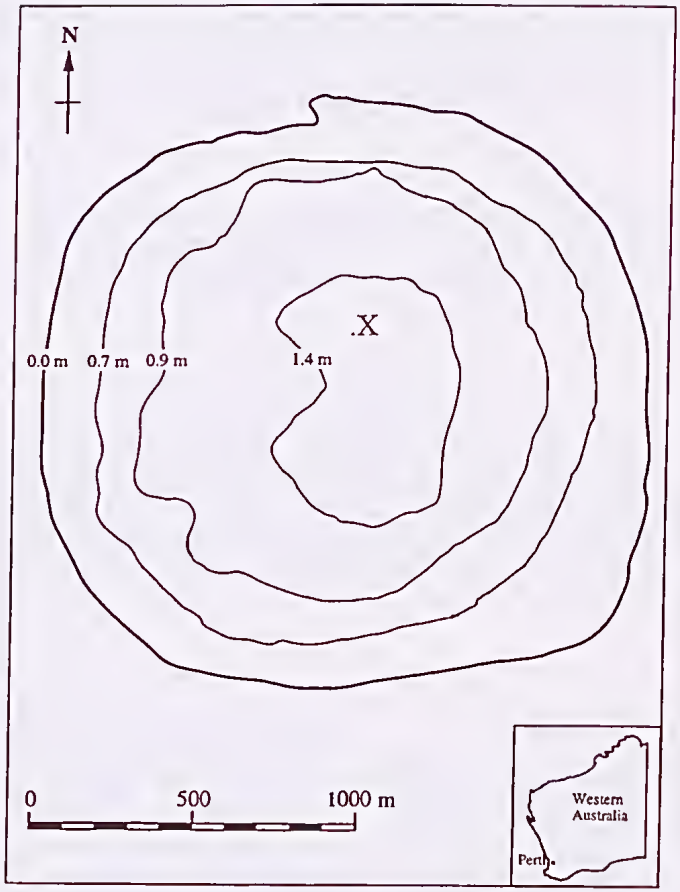

Figure 1. Location and bathymetry of Thomsons Lake. The data in this paper was collected at the station marked (X).

The closely packed eggs were attached to the surface of submerged plants and objects by the stalks. Voucher specimens of these eggs have been preserved at the Department of Zoology of the University of Western Australia. A macroinvertebrate monitoring program conducted in Thomsons Lake in October 1994 (Cheal & Davis, 1995) also confirmed the presence of at least two species of Corixidae, *Agraptocorixa eurynome* (Kirkaldy) and *Micronecta robusta* (Hale).

DESCRIPTION OF STUDY SITE

Thomsons Lake (Fig. 1), is shallow (maximum depth ~ 1.5 m), flat bottomed and approximately circular (diameter ~1600 m). The lake is 20 km south of Perth, Western Australia and 7 km inland from the Indian Ocean. It is primarily a surface expression of

the water table but it is also fed by some very small surface tributaries that enter the lake through the surrounding rush beds. The lake forms a part of a large chain of wetlands on the Swan Coastal Plain, described by Balla (1994). It is presently considered to be becoming eutrophic, due in part to pressure from urbanisation (Cheal & Davis, 1995).

MATERIALS AND METHODS

A small platform was erected above the waterline in 1.4 m of water at the location shown in Fig. 1. This platform was used for the deployment of a Grant/Yellow Springs Instruments (YSI) model 3800 SONDE and logger at a depth of 0.9 m. This instrument was used to measure dissolved oxygen, turbidity, pH, temperature and conductivity. The dissolved oxygen probe was equipped with a mechanical stirrer which vibrated vigorously and as a consequence the membrane of the probe was prevented from becoming fouled. Turbidity is a measurement of the scattering of light in the water column. In the turbidity probe a light signal passes through a bundle of optic fibers and the reflected back scatter of light is measured via the same optic fibers. Any fouling of the ends of these fibers would result in an increase in the measured turbidity proportional to the amount of fouling. The increase in measured turbidity would remain until the sensors were cleaned.

Figure 2. Unhatched eggs (Hemiptera: Corixidae) taken from the YSI/SONDE probe housing. The diameter of the eggs is approximately 0.6 – 1 mm and the stalk length is approximately 1 mm.

RESULTS AND DISCUSSION

On 15 November 1994 (day 319) it was noted that a small number of eggs had been laid on the platform legs below the water level. On a return visit on 22 November 1994 (day 326) the probes in the SONDE were found to be fouled with eggs with the exception of the vibrating dissolved oxygen probe. The platform legs below the water level were also thickly coated with eggs. Figure 3 shows the probes and the probe housing after the egg laying event, there are a large number of eggs attached to the probe housing. The turbidity probe is visible in the foreground. There were some eggs laid on the surface of the optic fiber bundle which is 6 mm in diameter.

Figure 3. The YSI/SONDE probe, 22 November, 1994. Clusters of eggs can be seen attached to the probes and the probe guard (top). The turbidity probe is foremost and the dissolved oxygen probe is to the left of the turbidity probe.

Because the turbidity probe is small, a single egg (0.6 – 1 mm diameter) laid on the bundle of optic fibers would be sufficient to cause a step up in turbidity readings.

Figure 4 shows a discontinuous sequence of turbidity data measured between day 296 and 326. The increase in turbidity between day 306 and day 318 was a result of an increase in phytoplankton concentration and matched corresponding increases in chlorophyll *a* and light attenuation (Bailey and Hamilton, in press). However, the most prominent feature of the figure is the four stepped increases in turbidity, commencing at the end of day 320. The large jumps in turbidity measurements were caused by eggs being laid on the exposed ends the optical fibers of the turbidity probe. Because turbidity was recorded at 15 minute intervals, the times at which clusters of eggs were laid can easily be determined. Higher resolution turbidity measurements together with other relevant parameters give a more complete picture of the fouling event. In Fig. 5a, the first step in turbidity occurs

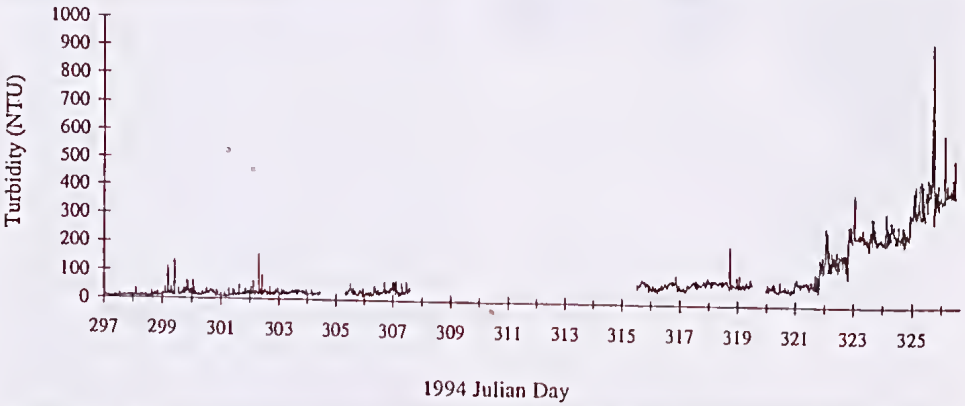

Figure 4. A sequence of turbidities measured at 15 minute intervals in nephelometric turbidity units (NTU). The effects of fouling on turbidity probe measurements are illustrated by the values recorded after day 320.

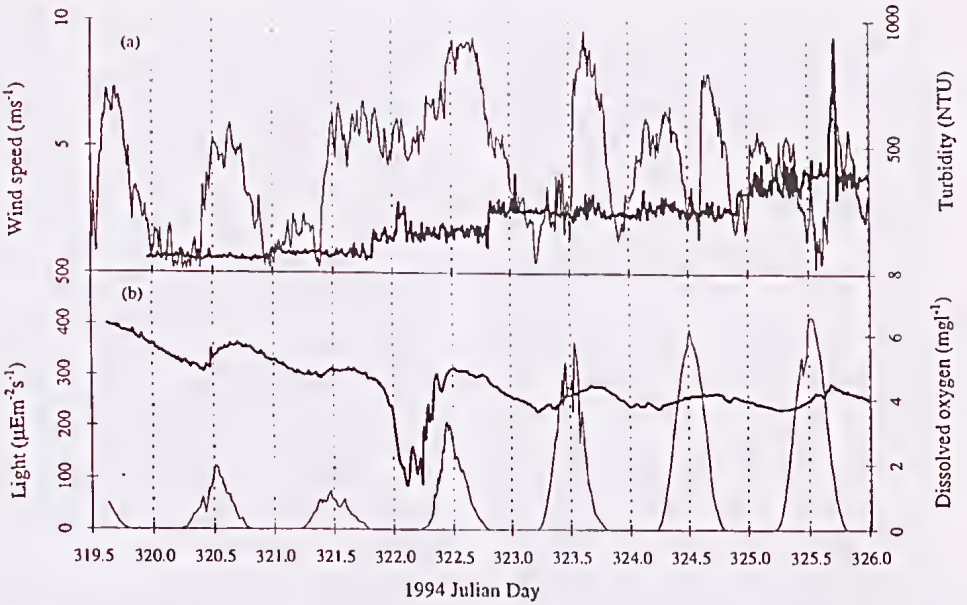

Figure 5. Physical data sequences pertaining to the oviposition event, day 319 to day 324 of 1994 (16 November to 20 November); (a) the fine line is wind speed 10 m above water surface (ms^{-1}) and the heavy line is turbidity at a depth of 0.45 m, in nephelometric turbidity units (NTU); (b) the fine line is light intensity measured 0.3 m below the water surface ($\mu Em^{-2}s^{-1}$) and the heavy line is dissolved oxygen (mgl^{-1}) at a depth of 0.45 m.

just before 24:00 h on day 320, larger steps occurred in the half hour following sunset on day 321 and after sunset the following evening of day 322 and the last recorded step occurs late in the evening (21:00 h) of day 324. The implied rhythm of oviposition is circadian, which is similar to that observed in many other insect species (Saunders, 1982).

Turbulent conditions did not appear to have an effect on the egg laying as thermistor chain data showed that the lake was isothermal vertically, experiencing fully turbulent mixing on days 322 and 323, with wind speeds at 10 m height exceeding 5 ms^{-1} (see Fig. 5a).

Measurements of dissolved oxygen concentration in Thomsons Lake showed a diurnal cycle typical of productive lakes (Fig. 5b). The dissolved oxygen concentrations would reach a maximum prior to dusk due to the photosynthetic activity of the phytoplankton, and a minimum prior to sunrise due to respiration (George, 1961; Wetzel, 1983). There were long term drifts in the dissolved oxygen concentration due to growth and mortality of phytoplankton populations (chlorophyll *a* concentrations ranged from 20 µg/L to 67 µg/L), changes in water temperature (range: 15 °C to 26 °C), mixing events and gradual deterioration of the oxygen probe membrane. However, we have no previous

recorded instances of an overnight depression of the scale of the one observed at Thomsons Lake in the early morning of 18 November (day 322).

During the time of the oviposition event the lake flora was dominated by two algal species, *Microcystis aeruginosa*, which was increasing in concentration, and *Anabaena circinalis*, which was abundant but declining in concentration (Bailey and Hamilton, in press). This depression is not explained by the collapse of a phytoplankton bloom as the dissolved oxygen values return to the longer term trend in the period following day 322. A large collapse of a bloom and the associated oxygen uptake would have had a longer term effect on the measured concentrations of dissolved oxygen in the lake.

We believe that the depression in dissolved oxygen is symptomatic of increased uptake due to respiration of the aquatic biota. In this instance we attribute it to the presence of the Corixidae, which have the ability to remain submerged for sustained periods by breathing air from a bubble trapped against their body. This bubble functions as a physical gill, theoretically capable of drawing nearly 13 times the original oxygen volume from the surrounding water through the bubble surface. Reviews of this mechanism can be found in Hinton (1981) and Ward (1992). As the drop in dissolved oxygen occurs at a period when the turbidity data suggests that oviposition was occurring, this explanation seems the most plausible.

We postulate that the majority of the eggs were laid on the probes during the oviposition event recorded on day 322 and that the drop in dissolved oxygen on this day was a highly localised event, due solely to a swarm of Corixidae present in and around the probe housing which laid the bulk of the eggs seen in Figure 3. Further steps up in turbidity on subsequent days were due to a continuation of the oviposition with a circadian rhythm, albeit at a reduced level of activity. The turbidity data only allows us to comment when steps occurred and the absence of steps in turbidity data on days 323 and 324 doesn't necessarily imply an absence of oviposition. The probe is small and the probability of eggs being deposited on it is obviously reduced if few Corixidae are present.

The time of the largest recorded oviposition event also coincided with a full moon on 18 November, 1994 (day 322) which could be due to the Corixidae sharing a trait with other aquatic insects in exhibiting periodicity with the moon, e.g., *Povilla adusta* (Corbet et al., 1974) and *Clunio marinus* (Neumann, 1976). However, there is no evidence in the literature to support this as a feature of Corixidae behaviour, nor is there any obvious environmental or evolutionary explanation.

CONCLUSION

A sequence of data collected from instruments fouled by an oviposition event from water bugs of the family Corixidae has provided insight into the ecology of the bugs. Turbidity data suggest that oviposition occurred with a circadian rhythm and that the preferred time for oviposition was the evening. Turbulent conditions did not appear to impede oviposition. An abnormally large drop in dissolved

oxygen concentration on one night is best explained by an increase in respiration due to oviposition by large numbers of water bugs near the oxygen sensor, the insect drawing oxygen from the surrounding water using its attached air bubble as a physical gill.

ACKNOWLEDGEMENTS

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